Study Methodology

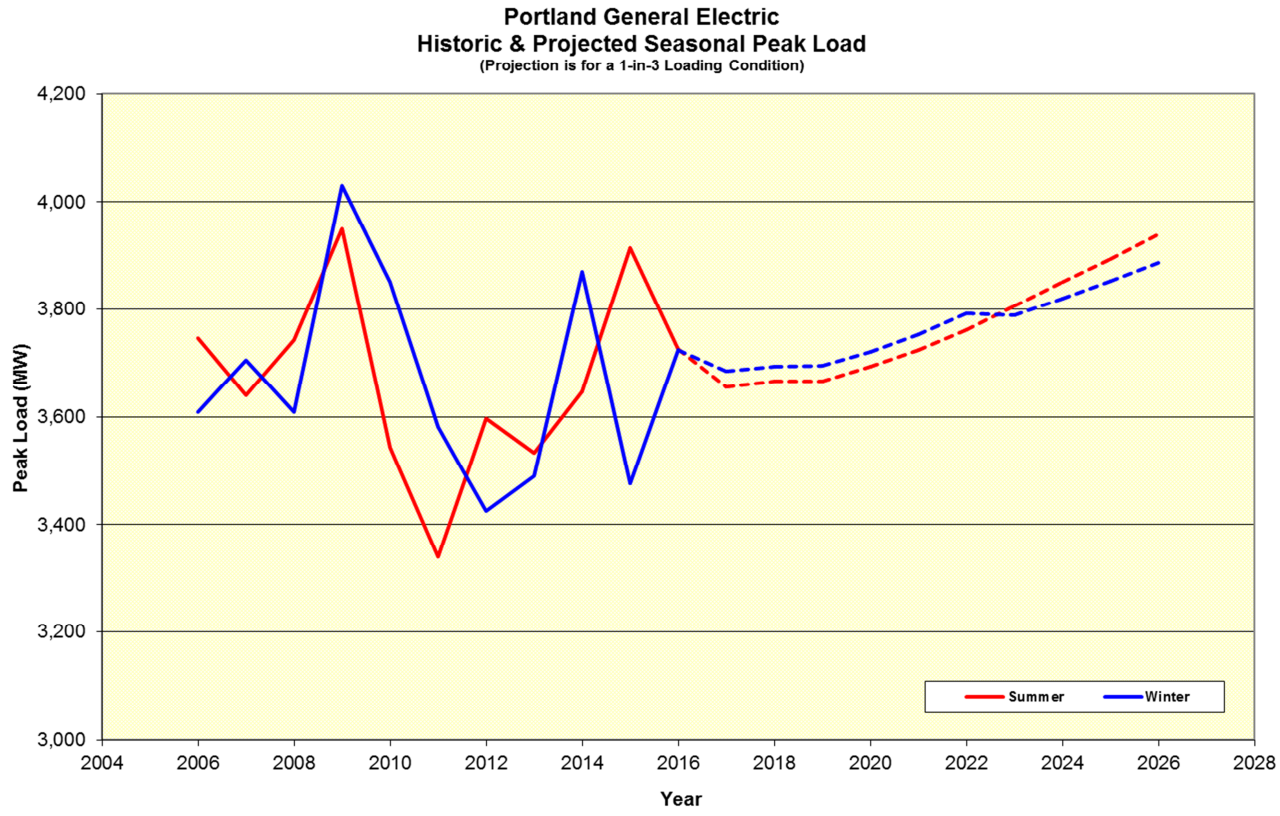
PGE's transmission system is designed to reliably supply projected customer demands and projected Firm Transmission Services over the range of forecast system demands. Studies are performed annually to evaluate where transmission upgrades may be needed to meet the performance requirements established in the NERC TPL-001-4 reliability standard.

The summer (June 1st through October 31st) and winter (November 1st through March 31st) load seasons are considered the most critical study seasons due to high power transfers over PGE's T&D System to its customers. PGE defines the seasons to align with the Peak Reliability Seasonal System Operating Limits Coordination Process, Appendix 'V'.

Summer and winter loading conditions and the corresponding daily averaged temperatures are as follows:

Summer	
1-in-2	79°F
1-in-3	81°F
1-in-5	83°F
1-in-10	85°F
1-in-20	87°F

Winter	
1-in-2	28°F
1-in-3	24°F
1-in-5	21°F
1-in-10	18°F
1-in-20	15°F



PGE maintains system models within its planning area for performing the studies required to complete the System Assessment. These models use data that is provided in WECC Base Cases in accordance with the MOD-010-0 and MOD-012-0 reliability standards. Electrical facilities modeled in the cases have established normal and emergency ratings, as defined in PGE's Facility Ratings Methodology document. A facility rating is determined based on the most limiting component in a given transmission path, in accordance with the FAC-008-3 reliability standard.

Studies are evaluated for the Near Term Planning Horizon (years 1 through 5) and the Long Term Planning Horizon (years 6 through 10) to ensure adequate capacity is available on PGE's transmission system. The load model used in the studies is obtained from PGE's corporate forecast, reflecting a 1-in-3 demand level for peak summer and peak winter conditions. Known outages of generation or transmission facilities with durations of at least six months are appropriately represented in the system models. Transmission equipment is assumed to be out of service in the Base Case system models if there is no spare equipment or mitigation strategy for the loss of the equipment.

In the Near Term, studies are performed for the following:

- System Peak Load for either Year One or Year Two
- System Peak Load for Year Five
- System Off-Peak Load for one of the five years

Sensitivity studies are performed for each of these cases by varying the study parameters to stress the system within a range of credible conditions that demonstrate a measurable change in performance. PGE alters the real and reactive forecasted load and the transfers on the paths into the Portland area on all sensitivity studies. For peak system sensitivity cases, the 1-in-10 load forecast is used.

Studies are evaluated at peak summer and peak winter load conditions for one of the years in the Long Term Planning Horizon.

The powerflow cases used in this year's assessment are described below. Topology, generation, and load changes are implemented to modify the cases as needed.

		Study Year	Origin WECC Base Case	PGE Case Name	PGE System Load (MW)
SUMMER	Year One/Two Case	2019	2021 HS2	19 HS PLANNING	3665
	Year Five Case	2022	2022 HS1	22 HS PLANNING	3762
	Year One/Two Sensitivity	2019	2021 HS2	19 HS SENSITIVITY	3789
	Year Five Sensitivity	2022	2022 HS1	22 HS SENSITIVITY	3889
	Long Term Case	2027	2027 HS1	27 HS PLANNING	3986
WINTER	Year One/Two Case	2018-19	2020-21 HW1	18-19 HW PLANNING	3694
	Year Five Case	2022-23	2021-22 HW2	22-23 HW PLANNING	3792
	Year One/Two Sensitivity	2018-19	2020-21 HW1	18-19 HW SENSITIVITY	3879
	Year Five Sensitivity	2022-23	2021-22 HW2	22-23 HW SENSITIVITY	3981
	Long Term Case	2027-28	2026-27 HW1	27-28 HW PLANNING	3921
SPRING	Near Term Off Peak Case	2019	2017 LSP2-S	19 LSP PLANNING	2427
	Near Term Off Peak Sensitivity	2019	2017 LSP2-S	19 LSP SENSITIVITY	2427

The Bulk Electric System (BES) is evaluated for Steady-State and Stability Performance for planning events described in Table 1 of the NERC TPL-001-4 reliability standard. When system simulations indicate an inability of the systems to respond as prescribed in the NERC TPL-001-4 reliability standard,

PGE identifies projects and/or Corrective Action Plans which are needed to achieve the required system performance throughout the Planning Horizon.

Short circuit studies are performed annually addressing the Near Term Planning Horizon. If the short circuit current interrupting duty on a circuit breaker exceeds its Equipment Rating, PGE identifies projects and/or Corrective Action Plans which are needed to achieve the required system performance throughout the Near Term Planning Horizon.

Steady-State Studies

PGE performs steady-state studies for the Near-Term and Long-Term Transmission Planning Horizons. The studies consider all contingency scenarios identified in Table 1 of the NERC TPL-001-4 reliability standard to determine if the BES meets performance requirements. These studies also assess the impact of Extreme Events on the system expected to produce severe system impacts.

The contingency analyses simulate the removal of all elements that the Protection System and other automatic controls are expected to disconnect for each contingency without Operator intervention. The analyses include the impact of the subsequent tripping of generators due to voltage limitations and tripping of transmission elements where relay loadability limits are exceeded. Automatic controls simulated include phase-shifting transformers, load tap changing transformers, and switched capacitors and reactors.

Cascading is not allowed to occur for any contingency analysis. If the analysis of an Extreme Event concludes there is Cascading, an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences and adverse impacts of the event(s) is completed.

Capacity addition projects are developed when simulations indicate the system's inability to meet the steady-state performance requirements for P1 events. For P2-P7 events, PGE identifies distribution substations where manual post-contingency "load-shedding" may be required to ensure that the BES remains within the defined operating limits.

Stability Studies

PGE evaluates the voltage and transient stability performance of the BES for contingencies to PGE and adjacent utility equipment at 500kV and 230kV. The studies evaluate single line-to-ground and 3ϕ faults to these facilities, including generators, bus sections, breaker failure, and loss of a double-circuit transmission line. Extreme events are studied for 3ϕ faults with Delayed Fault Clearing.

For all 500kV and 230kV breaker positions, PGE implements high-speed protection through two independent relay systems utilizing separate current transformers for each set of relays. For a fault directly affecting these facilities, normal clearing is achieved when the protection system operates as designed and faults are cleared within four to six cycles.

PGE implements breaker-failure protection schemes for its 500kV and 230kV facilities; and the majority of 115kV facilities. Delayed clearing occurs when a breaker fails to operate and the breaker-failure scheme clears the fault. Facilities without delayed clearing are modeled as such in the contingency definition.

The transient stability results are evaluated against the performance requirements outlined in the NERC TPL-001-4 reliability standard and against the WECC Disturbance-Performance Table of Allowable Effects on Other Systems (Table I). The simulation durations are run to 20 seconds.

Table I. Disturbance-Performance Table of Allowable Effects on Other Systems

NERC[1] and WECC Categories	Outage Frequency Associated with the Performance Category	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard
A (P0)	Not Applicable	Nothing in addition to NERC		
B (P1)	≥ 0.33	Not to exceed **25%** at load buses or **30%** at non-load buses. Not to exceed **20% for more than 20 cycles** at load buses.	Not below **59.6 Hz** for 6 cycles or more at a load bus.	Not to exceed **5%** at any bus.
C (P2-P7)	0.033-0.33	Not to exceed 30% at any bus. Not to exceed 20% for more than 40 cycles at load buses.	Not below **59.0 Hz** for 6 cycles or more at a load bus.	Not to exceed **10%** at any bus.
D (Extreme)	< 0.033	Nothing in addition to NERC		

Contingency analyses simulate the removal of all elements that the Protection System and other automatic controls expected to disconnect for each contingency without Operator intervention. The analyses include the impact of the subsequent:

- Successful high speed (less than one second) reclosing and unsuccessful high speed reclosing into a Fault where high speed reclosing is utilized
- Tripping of generators due to voltage limitations
- Tripping of Transmission lines and transformers where transient swings cause Protection System operation based on generic or actual relay models

[1] The WECC TPL-001-WECC-CRT Regional Criterion is currently undergoing a revision to adapt the new categories (P0-P7) in the NERC TPL-001-4 reliability standard.

Automatic controls simulated include generator exciter control and power system stabilizers, static var compensators, power flow controllers, and DC Transmission controllers.

Cascading is not allowed to occur for any contingency analysis. If the analysis of an Extreme Event concludes there is Cascading, an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences and adverse impacts of the event(s) is completed.

Corrective Action Plans are developed if the stability studies indicate that the system cannot meet the TPL-001-4 and WECC performance requirements.

- P1: No generating unit pulls out of synchronism
- P2-P7: When a generator pulls out of synchronism, the resulting apparent impedance swings do not result in the tripping of any Transmission system elements other than the generating unit and its directly connected facilities
- P1-P7: Power oscillations exhibit acceptable damping